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STRATEGY FOR MANAGEMENT OF ORNL PROCESS WASTEWATER

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INTRODUCTION

The process waste system at Oak Ridge National Laboratory (ORNL) collects and treats large volumes of wastewater which could potentially be contaminated with hazardous materials or low levels of radioactivity. Waste management operations include segregation, collection, and treatment of process waste generated by research facilities, remedial actions, programs, and waste treatment facilities. The objectives of the ORNL process waste management plan are to:

1. Provide treatment facilities to process all present and future process waste for discharge to the environment,
2. Meet applicable regulatory requirements,
3. Segregate and divert waste streams to the appropriate waste treatment facilities, and,
4. Increase the efficiency of the treatment facilities to reduce the amount of total secondary waste generation with a major emphasis on reducing or eliminating the production of liquid low-level waste (LLLW).

Studies began in the mid 1980s to develop a strategy for upgrading the process waste system. These studies and the resulting strategy are described in this report.

PROCESS WASTEWATER TREATMENT FACILITIES

ORNL process wastewater consists of tap water and groundwater which is slightly contaminated with hazardous or radioactive materials. The major chemical constituents are bicarbonates of calcium, magnesium, and sodium, as shown in Table 1; and the average concentration of the radionuclide contaminants are shown in Table 2. The wastewater may also contain trace quantities of heavy metals or organic materials; typical concentrations are shown in Table 3. The concentration of any of these contaminants can

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Table 1. Major chemical constituents in process wastewater

Component	Concentration (mg/L)	Component	Concentration (mg/L)
Ca^{2+}	40	HCO_3^-	93
Mg^+	8	SO_4^{2-}	23
Na^+	5	Cl^-	10
K^+	2	NO_3^-	11
Si^{3+}	2	CO_3^{2-}	7
Sr^{2+}	0.1	F^-	1

Table 2. Typical radiochemical composition of process wastewater

Radionuclide	Concentration (Bq/L)
Gross alpha	30
Gross beta	3500
^{60}Co	25
^{90}Sr	2000
^{106}Ru	10
^{137}Cs	200

Table 3. Typical concentration of contaminants in process wastewater

Substance	Concentration (mg/L)
Ag	0.021
As	0.075
B	<0.08
Ba	0.081
Be	<0.0003
Cd	<0.007
Cr	0.026
Cu	0.27
Fe	11.0
Hg	<0.15
NO_3 as N	12
Ni	0.07
Pb	0.18
Sb	<0.05
Se	<.042
SO_4	210.0
Zn	0.94
COD[a]	6.0
TOC[b]	2.5

[a]COD = Chemical Oxygen Demand
[b]TOC = Total Organic Carbon

vary by orders of magnitude. Radioactive wastewater is treated at the Process Waste Treatment Plant (PWTP). Although the PWTP removes some hazardous materials as a secondary effect of radionuclide treatment, the majority of the hazardous materials are removed from nonradioactive process wastewater (including the PWTP effluent) at the Nonradiological Wastewater Treatment Plant (NRWTP). The PWTP is covered by permit-by-rule, and the NRWTP will be covered by permit-by-rule after the required paperwork has been submitted to the Tennessee Department of Health and Environment (TDHE) under the Resource Conservation and Recovery Act (RCRA), according to the provisions of permit-by-rule (TN Rule 1200-1-11-.07(1)c and 40 CFR 270.60). Process waste system discharge limits for nonradioactive materials are set by the NPDES permit. Radionuclide discharges are limited by DOE Order 5400.5, which sets derived concentration guidelines (DCG) below which treatment is not required. Streams with radionuclide concentrations above the DCG value require treatment by "best available technology" methods. ORNL uses DCG values as operating discharge limits at the NRWTP monitoring station.

Process Waste Treatment Plant

Slightly contaminated process wastewater has been routinely treated by filtration and ion exchange processes. From the mid 1970's to 1986, process wastewater was filtered through anthracite filters, with radionuclide removal by ion exchange. The ion-exchange resin was regenerated with nitric acid. The resulting eluate was concentrated by evaporation and transferred to LLLW system for storage as LLLW concentrate (LLLWC). Typical compositions of LLLW produced by this process are listed in Table 4.

Treatability studies[1] performed in 1985 indicated that the LLLW generation rate could be reduced by upgrading of the PWTP by installing a surplus reactor/clarifier to remove nonradioactive cations from the feed prior to treatment for removal of radionuclides. The flowsheet has been used since 1986 and consists of chemical precipitation, filtration, and ion- exchange processes as shown in Fig. 1. Most of the calcium and magnesium, along with a fraction of the radionuclides, are precipitated in the clarifier at pH 11.4. The resulting sludge is dewatered in a filter press for interim storage

Table 4. Typical nonradiological composition of PWTP evaporator concentrate prior to 1986[a]

Ca	0.041
Mg	0.011
K	0.002
Na	0.010
NO_3^-	0.43
Free HNO_3	2.84 N
Sp. Gr.	1.357
Total Solids	0.534

[a]Units are in g/g unless stated otherwise.

and ultimate disposal as solid low-level radioactive waste. Removing the major nonradioactive cations from the waste stream in the clarifier extends the life of the ion exchange columns and reduces the production of LLLW since the columns are regenerated less frequently. Installation of the reactor/clarifier reduced PWTP secondary waste generation rates from 50,000 gal/yr (189 m^3/yr) of LLLWC to 8,000 gal/yr (30 m^3/yr) of LLLWC plus 3,900 ft^3/yr (110 m^3/yr) of solid low-level waste (clarifier sludge). A typical composition of the LLLW produced by this process is given in Table 5. Installation of the reactor/clarifier had two negative impacts: it limited the plant flow rate to 160 gpm (606 L/m) and lowered the capability of the ion-exchange resin to remove Cs-137 due to the increased levels of sodium in the clarifier effluent.

Nonradiological Wastewater Treatment Plant

In February 1990, the NRWTP began treating nonradiological process wastewater (including the effluent from the PWTP) for heavy metals and organics. The flowsheet, shown in Fig. 2, consists of chemical precipitation, which removes heavy metals, air stripping, which removes volatile organics, and carbon columns, which remove nonvolatile

Table 5. Typical composition of PWTP evaporator concentrate after 1986[a]

	December 1987	May 1988
Ca	0.05	
K	0.0014	
Mg	0.029	
Na	0.048	
Sr	0.0005	
Total NO_3^-	0.54	0.67
Ba	60	
Cr	44	
Ni	24	
H^+	1.36 N	1.82 N
Sp. Gr.	1.433	1.51
TDS[b]	680 g/L	
Gross Alpha	1.0E5 Bq/L	
Gross Beta	7.4E6 Bq/L	8.3E6 Bq/L
Gross Gamma	2.0E5 Bq/L	
Co-60	1.8E3 Bq/L	
Cs-137	1.48E5 Bq/L	
Eu-152	5.6E3 Bq/L	
Eu-154	2.3E3 Bq/L	
Eu-155	5.0E2 Bq/L	

[a]Units in g/g unless stated otherwise.
[b]TDS = Total Dissolved Solids

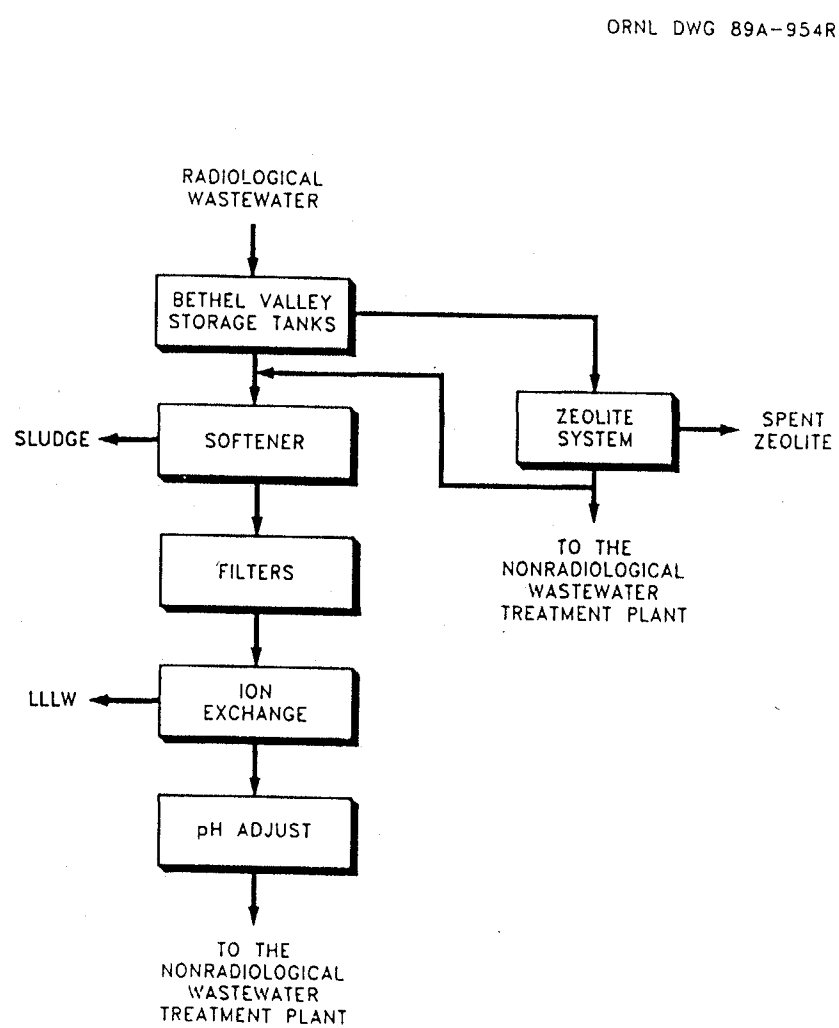

Fig. 1. Flowsheet for the existing Process Waste Treatment Plant.

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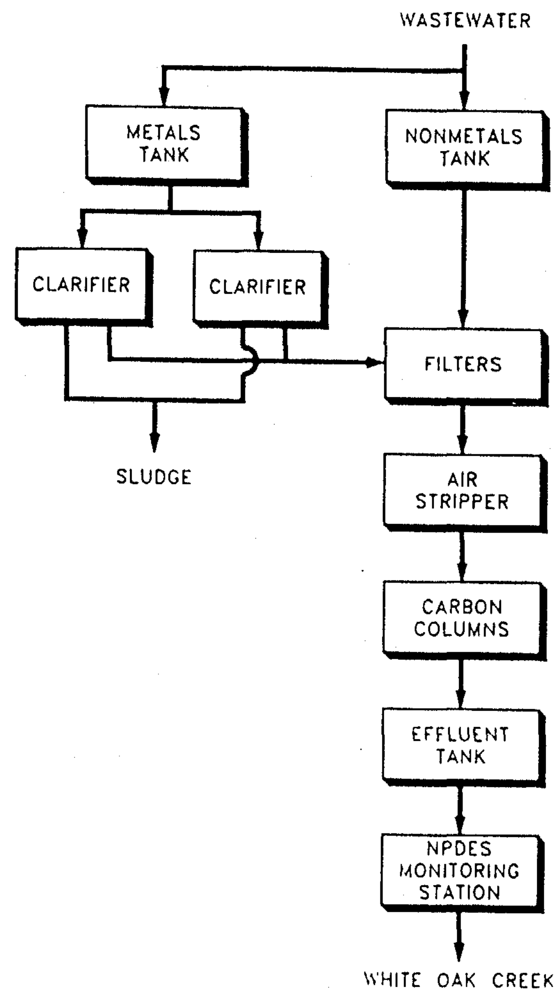

Fig. 2. Flowsheet for the existing Nonradiological Process Waste Treatment Plant.

organics. The plant has the capacity to treat 740 gal/min (2800 L/min) of wastewater. Since only a small percentage of the total influent wastewater to NRWTP requires metals removal, wastewater containing low concentrations of metals are diverted around the clarifier to reduce treatment costs and sludge production. Typical influent compositions are given in Table 3. The effluent is discharged to White Oak Creek, and the secondary waste (sludge and activated carbon) is being stored for disposal as solid low-level radioactive waste. Typical effluent compositions, along with present discharge limits and Tennessee Water Quality Standards (WQS), are shown in Table 6. The TDHE may request that the NRWTP meet effluent limits based on WQS in the future. The potential impacts are discussed later in this report.

UPGRADE REQUIREMENTS

The need for upgrades to the process waste system is driven by several operating and regulatory requirements. These are summarized below:

Process Waste Treatment Plant

Cs-137 Removal. For the last several years, the discharge limits for radionuclides have been set at 11.1 Bq/L for Sr-90 and 740 Bq/L for Cs-137 by 10CFR20. The present PWTP flowsheet (Fig. 1) treats for Sr-90, but does not remove Cs-137. Under normal operating conditions, the PWTP feed has met the cesium discharge limit without treatment. However, DOE Order 5400.5, which became effective in February 1990 and supercedes 10CFR20, changed the discharge limits for Sr-90 and Cs-137 to 37 Bq/L and 111 Bq/L, respectively. Prior to the shutdown of 3517, the PWTP could not have met the new Cs-137 discharge limits. Since the shutdown of 3517, the PWTP effluent averages 70 Bq/L Cs-137. However, it is not unusual for the PWTP effluent to reach the new discharge limits. Treatment for Cs-137 removal is needed at the PWTP. Effluent concentrations of the other radionuclides are negligible and are well below discharge requirements.

LLLW Reduction. Since there is limited storage capacity in the tanks that are being used to store LLLW, reducing the generation rate of LLLW has been identified as a

Table 6. Typical composition of nonradiological wastewater treatment plant effluent[a]

Substances	NPDES Permit[b]	Proposed WQS[c]	NRWTP Effluent
Ag	0.43	0.0041	<0.005
As	--	0.36	<0.05
B	--	1	<0.08
Ba	--	1	<0.012
Be	--	0.13	<0.0003
Cd	0.69	0.0039	<0.007
Cr	2.77	0.05	0.008
Cu	3.38	0.018	0.02
Fe	--	1	0.075
Hg	--	0.0024	0.0001
NO_3 as N[d]	--	10	12
Ni	3.98	1.4	<0.009
Pb	0.69	0.082	<0.05
Sb	--	9	<0.05
Se	--	0.02	<0.04
SO_4	--	250	130
Zn	2.61	0.12	0.19
TTO[e]	2.13	---	0.1

[a]Concentrations given in mg/L.
[b]Maximum daily discharge.
[c]The Tennessee Department of Health and Environment may set future discharge limits at Water Quality Standards (WQS).
[d]Drinking Water Standards. No WQS standard has been proposed by TDHE.
[e]TTO = Total Toxic Organics.

major short-term goal in the management strategy of LLLW.[2] Studies[3,4] performed in 1987-1989 determined that the PWTP is the primary generator of dissolved solids and nitrates in LLLW, but contributes a negligible amount of radioisotopes. In addition, only two LLLW generators were primarily responsible for limiting the volume reduction factor obtained at the LLLW evaporator: the PWTP and the Fission Products Development Laboratory (Building 3517). Since 3517 shutdown, the PWTP and the Radiochemical Engineering Development Center are the two primary contributors. Since the removal of PWTP waste would have the single largest effect on the volume and concentration of nonradioactive components in the LLLWC, it was targeted for upgrade to reduce LLLW production.

DOE Order 5820.2A requires that each DOE site prepare and maintain an overall waste management systems performance assessment to support reduction, segregation, tracking, and minimization of waste. ORNL is specifically required to reduce the gross volume and/or amount of mixed, TRU, low-level, and high-level waste requiring disposal. Since the PWTP is the major generator of LLLW, the Order supports upgrading the process system to reduce LLLW production.

FFA. The draft Federal Facilities Agreement (FFA) between the TDHE, the Environmental Protection Agency, and DOE requires that the PWTP evaporator surge/storage tank and LLLW transfer lines be doubly contained and meet certain leak detection requirements. Upgrades will be required to meet these requirements.

Capacity Increase. A temporary zeolite system was installed in 1986 to allow for treatment of Cs-137 in emergency situations. The zeolite system has also been used in parallel with the existing treatment system to increase the plant capacity from 160 gpm to 220 gpm (605 to 833 L/min) to meet peak demands. This system cannot be used indefinitely and must be replaced by a permanent system. Therefore, the PWTP must be upgraded in the near-term to increase plant capacity and remove Cs-137.

Equipment Repair. Having been in continuous use since 1975, the PWTP is in general need of repair. Pumps, piping, tanks, the evaporator system, and much of the building must be replaced or repaired over the next few years. Additional spill control and diking is also needed.

Nonradiological Wastewater Treatment Plant

Since the NRWTP is a new facility, it meets existing regulatory and operational needs. However, the NPDES permit for the facility is renegotiated with the TDHE every five years. The original NPDES permit for the NRWTP was obtained in 1986 before the plant was operational so the discharge limits were set at relatively high values for plant startup. Future permits are likely to be increasingly stringent, and plant upgrades may be required to meet new discharge limits.

STRATEGY

ORNL process wastewater management objectives are:

1. Implement Cs-137 treatment capabilities at the PWTP to meet DOE Order 5400.5,
2. Increase the PWTP treatment capacity from 160 gpm to 300 gpm (605 to 833 L/min) to meet peak load demands by replacement of the clarifier,
3. Implement improvements at the PWTP to meet FFA and safety requirements,
4. Increase the efficiency of the process waste system to reduce the amount of total secondary waste generation with a major emphasis on reducing or eliminating LLLWC generation,
5. Accommodate new waste streams expected in the future,
6. Segregate and divert waste streams to the appropriate waste treatment facilities to reduce secondary waste generation, and
7. Implement waste management plans to meet DOE Order 5820.2A.

Process Waste Treatment Plant

The long-term strategy for treatment of radioactively contaminated process wastewater is to replace the PWTP flowsheet with a filtration system and zeolite ion exchange columns for removal of cesium and strontium as shown in Fig. 3. This would meet the first four objectives listed. Estimated secondary waste generation rates for this process (based on bench-scale results) would be approximately 40% of that produced by

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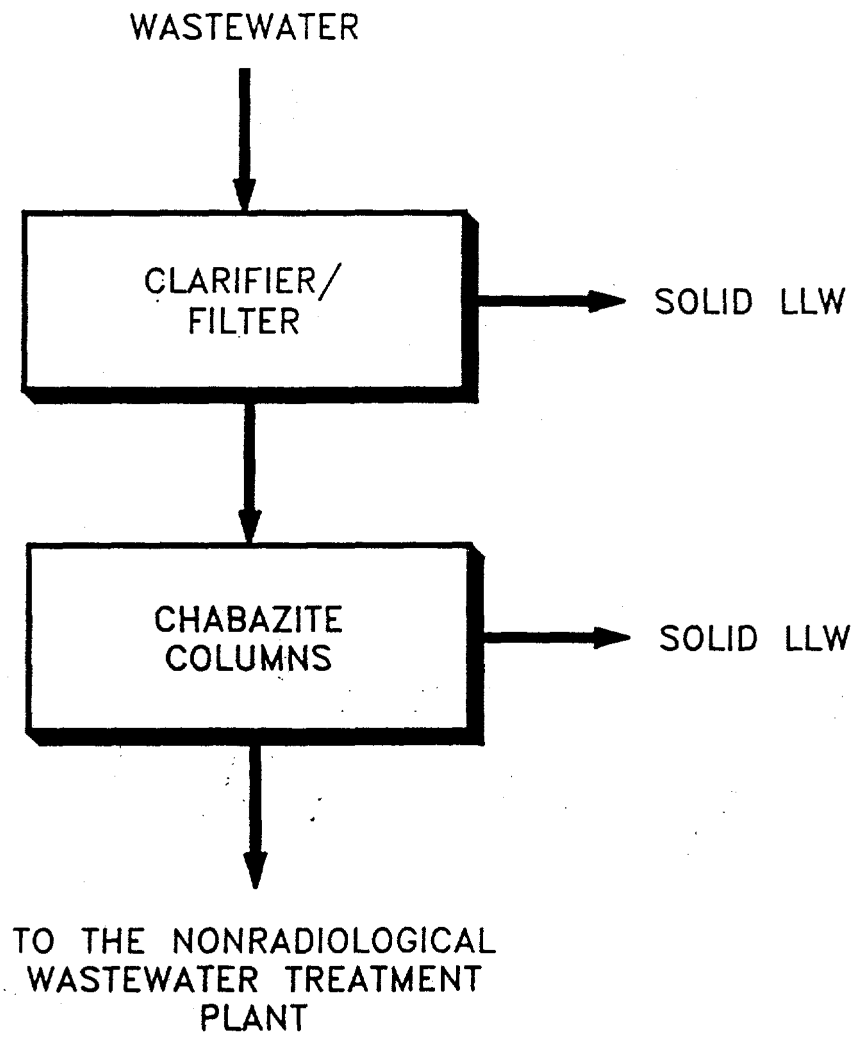
PROPOSED CHABAZITE FLOWSHEET FOR WASTEWATER TREATMENT



the PWTP flowsheet (as shown in Fig. 1) and would eliminate production of LLLWC at the PWTP. Studies indicate this process cannot be implemented before 6-10 years (see Strategy Implementation).

The strategy, therefore, calls for near-term GPP upgrades at the PWTP to meet the first three objectives listed above in a timely manner. This includes upgrades to the PWTP to improve operability and reduce safety risks, reduce secondary waste generation, increase the feed capacity of the existing plant, implement Cs-137 treatment capabilities, and add secondary containment to the evaporator tanks and LLLW transfer lines until the strontium/cesium zeolite plant comes on line. These upgrades will be made in such a manner as to allow reuse of some of the existing equipment at the new zeolite plant in order to reduce capital costs.

Until recently, it was assumed that the only decontamination processes needed at the PWTP were for cesium and strontium. Recent indications are that the waste generated at the centralized Class I Landfill Leachate Waste Decontamination Facility (LLWDF) might be processed at the PWTP. In addition to contaminants treatable by the PWTP and NRWTP, this waste would also contain technetium. Wastes from the Advanced Neutron Source reactor and the Remedial Actions Program are also likely to contain nitrate and cobalt. The long-term strategy for treatment of LLLWC consists of a flowsheet which would produce a process wastewater containing cobalt and nitrate. If the centralized waste treatment facilities are not upgraded to treat these contaminants, each of these waste generators would have to implement source treatment for all contaminants except strontium or cesium. Since these waste streams contain similar contaminants, it would be more efficient to install centralized unit operations to remove them. As the above streams are likely to generate <100 gpm (<380 L/min) total, current plans are to install a pretreatment system for removal of technetium, cobalt, and nitrates upstream of the zeolite system. These streams will be segregated from the present process waste streams and will be transferred to the NRWTP by tanker truck or a new pipeline system. This will meet Objective 5 listed above.

Nonradiological Wastewater Treatment Plant

Some changes may also be required for the NRWTP when the NPDES permit is renegotiated. The present NPDES permit discharge limits are based on best available technology (BAT) for treating metal finishing wastewaters. These limits will be renegotiated in 1991. When the NPDES permit was granted in 1986, expectations were that the new discharge limits would be changed to values based on the NRWTP effluent data. Recent trends in the approach of TDHE to permit renewals have been to set the discharge limits at Water Quality Standards (WQS) in the receiving stream. Since White Oak Creek is considered to be a zero-flow stream under drought conditions, this approach would set the NRWTP discharge limits at the WQS values. Since White Oak Creek headwaters do not meet WQS for several components, the effluent from the NRWTP would have to be much lower than the WQS values in order to meet WQS in the receiving stream. Since the NRWTP was not designed to meet these WQS, major plant upgrades would be required to achieve such low discharge limits.

The waste management plan is to use plant effluent data and biotoxicity results for negotiating new NPDES permit limits. Plant effluent data will be evaluated statistically to determine discharge limits which the NRWTP can meet, and biotoxicity data will be used to show that these concentrations are not harmful to the environment. Upgrades are not presently being planned for the NRWTP, but these plans may change when future NRWTP NPDES permits are negotiated.

The present waste acceptance criteria for the process waste system were written before the NRWTP became operational and require segregation of all hazardous materials at the source. Administrative controls for discharge to process drains are being relaxed to allow treatable waste streams to enter the plant. New waste acceptance criteria for the NRWTP are being set at values which would not significantly increase present effluent concentrations based on plant data, laboratory test results, and literature data.

Waste Segregation and Administrative Controls

Objectives 6 and 7 listed above will be met by segregating process waste streams to eliminate inappropriate waste streams, implementing certification and tracking programs through administrative controls, and performing systems analyses to develop effective waste management plans.

STRATEGY IMPLEMENTATION

A number of development and economic studies have been performed to support the process waste system upgrade strategy and to determine the most appropriate method for its implementation. The resulting capital projects, summarized in Table 7, are described below.

Wastewater Segregation

A comprehensive survey of the liquid waste generators was conducted in 1989 to determine the volume and composition of liquid wastes being generated at ORNL. The survey identified several once-through cooling water (OTCW) streams produced by uncontaminated processes that were being sent to the PWTP for radionuclide removal. The nonradioactive cations (such as calcium and magnesium) in the OTCW are removed by the PWTP reactor/clarifier and ion exchange columns, thereby increasing the volume of radioactive sludge and LLLW generated at the PWTP. Removing OTCW streams from the radiological wastewater will reduce waste generation and improve treatment efficiency as required by DOE Order 5820.2A.

Segregation of OTCW from the process waste system is in progress. Energy Division implemented a project in 1989 to treat the OTCW from Building 3144 for chlorine removal at the source and discharge it to the storm sewer. This action removed 29,000 gpd (110 m^3/d) from the PWTP feed. An FY 1991 GPP is scheduled to remove an additional 25,900 gpd (98 m^3/d) of OTCW generated at Building 3003 from the PWTP feed. In addition, 28,800 gpd (109 m^3/d) of OTCW, which will be generated by a new process, will be treated locally in Building 3003. This GPP will significantly reduce both present and future throughput and secondary waste generation rates at the PWTP. An additional 6,800 gpd (26 m^3/d) of OTCW (<5% of the PWTP feed) originates from four different buildings and would be extremely expensive to segregate. At the present time, no plans are being made to implement segregation projects for these streams.

Table 7. Upgrade projects planned for the ORNL Process Wastewater Treatment System.

Project	ADS	WBS	Type	Funding Year	Costs, $K
West End Addition	349	3.59	GPP	FY 1988	593
OTCW Segregation	350	3.52	GPP	FY 1991	700
PWTP Improvements	350	3.38	GPP	FY 1991	765
PWTP Feed Capacity Increase	350	3.93	GPP	FY 1991	950
IE/E Room Upgrade	349	3.78	GPP	FY 1992	1,000
Nitric Acid Unloading	350	4.55	GPP	FY 1992	300
Cs Removal System	366	3.26	GPP	FY 1992	1,100
LLLW Piping Replacement		3.29	GPP	FY 1994	1,100
LLWDF Project	424	--	LI	FY 1992	18,000
PW Pretreatment	378	3.31	LI	FY 1995	15,000

Upgrade of the PWTP

Extensive treatability studies and alternative analyses have been conducted to support the PWTP process improvements. From 1986 through 1988, bench-scale treatability studies[1] were performed to determine the most feasible methods for upgrading the PWTP to meet more stringent discharge limits while reducing secondary waste generation. A combination of four chemical precipitation processes and 16 ion-exchange processes were tested for Cs-137 and Sr-90 removal. The ion exchange materials tested included weak-acid cation resins, strong-acid cation resins, specialty resins with selective properties for cesium and strontium, and natural and synthetic zeolites.

The results from these tests were used to develop four potential flowsheets which consisted of various filtration, precipitation, and ion-exchange unit operations for installation at the PWTP. Flowsheet analyses[5] showed that a series of chabazite zeolite ion-exchange columns to remove both Sr-90 and Cs-137 would be the most economical and efficient method for long-term treatment of radioactive process waste. The proposed flowsheet is shown in Fig. 3. The zeolite columns would be taken off-line when Sr-90 begins to break through, and they would be disposed of as Class II solid waste. Results from research studies show that the design and operation of the ion-exchange system is an extremely important factor in determining the efficiency of the process. Development work is currently underway to provide column data for design.

A study and estimate[6] was performed by MMES Engineering for installation of a strontium/cesium removal zeolite system at the PWTP. The results indicated that the project would cost $1.6M thus requiring line item funding. A follow-on study[7,8] evaluated additional options for installation of the zeolite system. The alternatives included building a new facility at an undeveloped site, installing zeolite columns at the NRWTP site, replacing the NRWTP carbon columns with zeolite columns, and modifying the NRWTP carbon columns for use as zeolite columns. The results of the study indicated that installing new zeolite columns at the NRWTP where the site would be uncontaminated and the NRWTP utilities, some equipment, and operators could be utilized would be preferable to installing zeolite columns at the aging PWTP. Preliminary cost estimates from Engineering indicated that installation of a permanent zeolite system at the NRWTP site would exceed the GPP funding limit and line-item funding would likely be required to install the zeolite system at the NRWTP site. The line item request for installation of the zeolite columns should also be used to install unit operations needed to treat future process waste streams (see PWTP Replacement Section below). Interim upgrades will be required to keep the existing PWTP operational until the zeolite system can be implemented as described below.

Interim Operational/FFA Upgrades. Several upgrades will be required to improve operability, reduce safety risks, and to meet the FFA requirements at the PWTP until it can be replaced by the new facility at the NRWTP site. These will be implemented by four GPPs. The "West End Addition" GPP will install a caustic unloading station, sulfuric acid unloading station, restroom facilities, and additional operating storage space. The "IE/E Room Upgrade" GPP will (1) doubly contain the PWTP evaporator tanks as required by the FFA, (2) provide secondary containment for PWTP process equipment such as acid tanks, L6, L2, filters, clear well, etc., (3) replace the evaporator, (4) add HEPA filtered exhaust for evaporator and filter press rooms. The "Nitric Acid Unloading" GPP will provide an acid unloading station for the facility. The "LLLW Piping" GPP will install doubly-contained piping from the PWTP evaporator to the centralized LLLW collection and transfer system or install a LLLW trucking station at the PWTP site to meet the FFA requirements.

Interim Evaporator System Upgrades. Evaluation of the PWTP evaporator system[9] indicated that simple upgrades could significantly reduce LLLWC waste generation. In the present process the loaded ion-exchange columns are regenerated with nitric acid. The eluate is concentrated in an evaporator at the PWTP site. The concentrate from the evaporator is transferred to the LLLW system for storage and ultimate disposal, while the overheads are recycled within the PWTP. Unfortunately, the current single-stage evaporator was not designed to recover nitric acid of sufficient strength to be used as regenerant solution. Therefore, the evaporator is operated to recover the amount of dilute nitric acid that can be mixed with concentrated nitric to produce the desired volume and concentration of regenerant solution. The extra eluate is neutralized with sodium hydroxide and transferred to the LLLW evaporator feed tank where it is combined with much less concentrated LLLW from other processes, evaporated, and stored for disposal. The volume reduction factor obtained by processing the eluate in the PWTP evaporator is 13, while it is less than 4 at the LLLW evaporator. Therefore, upgrading the PWTP evaporator system to allow for processing 100% of the eluate would significantly reduce the LLLWC production rate from the PWTP.

A study,[9] implemented to determine how this could be accomplished resulted in two alternative upgrade options: (1) installing a multiple-stage evaporator at the PWTP, and (2) installing an extra holding tank in the existing evaporator system. Replacing the existing single-stage evaporator with a multiple-stage unit would allow recovery of more concentrated nitric acid. This would allow total recycle of the evaporator condensate while processing all of the eluate at the PWTP. The resulting evaporator bottoms could be sent to the LLLW system for disposal or solidified at the PWTP site. This option was abandoned because neither the multi-stage evaporator nor the solidification equipment could be physically located in the existing PWTP building because of their size. The cost and time involved with installing these unit operations in a new facility would not allow immediate implementation. As an alternative, all of the eluate could be processed at the PWTP if an evaporator condensate holding tank was added to the present system. The overheads generated in excess of what would be needed for recycle could be collected in this tank and metered into the PWTP feed. This approach would be relatively inexpensive to implement, would reduce the LLLWC generation by 1500 gal/yr (5.7 m^3/yr), and would not significantly increase the nitrate concentration in the NRWTP effluent.

An FY 1991 GPP (PWTP Improvements) is in place to install an extra holding tank in the evaporator loop at the PWTP. A pH adjustment tank will also be installed between the PWTP reactor/clarifier and the ion-exchange columns. Increasing the pH of the clarifier effluent will stop the chemical precipitation reaction and, therefore, extend the life of the ion-exchange columns by reducing plugging problems.

<u>Interim Feed Capacity Upgrades</u>. While installation of the reactor/clarifier in 1986 improved the efficiency of the PWTP, it reduced the flow capacity of the plant from ~250 gpm to 160 gpm (946 to 606 L/m). Replacement of the unit would increase the feed capacity to meet peak demand. Economic studies indicate that a new clarifier cannot be installed at the PWTP for less than line item funding. An alternative would be to use a clarifier at the NRWTP to replace the existing clarifier. An FY 1991 GPP (Feed Capacity Increase) is in place to repipe and modify one of the NRWTP reactor/clarifiers for use in the PWTP flowsheet as shown in Fig. 4.

Improved waste management practices have reduced the amount of metals-containing wastewater requiring treatment at the NRWTP to approximately 5 gal/min (19 L/min). Since the NRWTP is equipped with two 380 gal (1440 L) reactor/clarifiers, the metals waste stream is being treated batchwise in one reactor/clarifier. The other NRWTP clarifier will be used in the PWTP flowsheet. It will then be possible to treat the small amount of metals-containing wastewater with the PWTP feed. Since the PWTP clarifier will be operated on a continuous basis, it should be more efficient than the present batch operation.

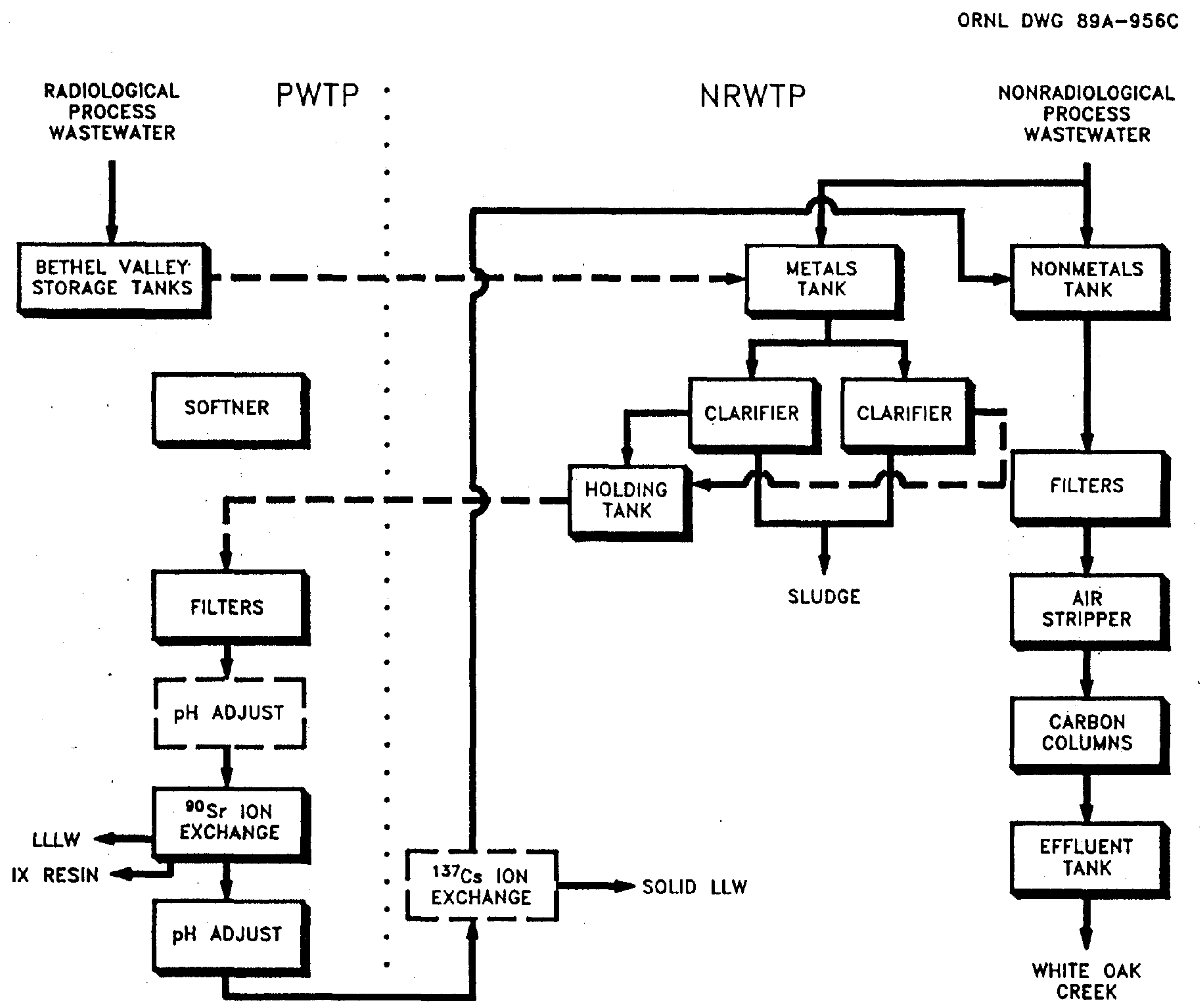


Fig. 4. Flowsheet for increasing the feed capacity of the Process Waste Treatment Plant.

Interim Cs-137 Removal Upgrades. Three options have been considered for near-term upgrades to increase Cs-137 removal capability while awaiting installation of the strontium/cesium zeolite system: (a) addition of zeolite columns to the existing plant, (b) replacing the ion-exchange resin presently used to remove Sr-90 with a resin that would remove both Cs-137 and Sr-90, and (c) precipitation of Cs-137 with a ferrocyanide compound.

Zeolite columns could be added downstream of the PWTP pH adjustment station to remove Cs-137. Since the selectivity of chabazite zeolite is extremely high for Cs-137, column change-out rates would be infrequent; and column design would be much more flexible than if strontium were also being removed. Disposable columns available from vendors could be economically installed in a diked area. Once loaded, columns would be dewatered and disposed of as solid waste. Pilot- and near-full-scale tests,[10,11] performed at the PWTP have confirmed the feasibility and simplicity of this process. The process will not increase the LLLW production, but will increase the solid waste generation rate by 20% from 3900 to 4700 ft^3/yr (110 to 133 m^3/yr). Replacing the HCR-S resin (the strong-acid cation exchange resin presently used in the PWTP to remove Sr-90) with CS-100 resin in the existing ion-exchange columns at the PWTP was considered as a cesium removal upgrade option. CS-100 resin is a specialty resin that will remove both cesium and strontium if the pH of the feed is adjusted to 12. This upgrade would be inexpensive to implement, but the less efficient resin would generate over four times more LLLWC than the HCR-S resin. Solid waste generation would not be reduced. It would also be much more complicated to operate.

The literature suggests that cesium can be removed by chemical precipitation using a ferrocyanide compound. Adding a ferrocyanide compound to the existing reactor/clarifier looks promising, but the process has not been demonstrated at ORNL and would require development work.

Installation of disposable zeolite columns was selected as the most appropriate treatment option for removal of Cs-137 (Fig. 5). Installation of temporary zeolite columns at the PWTP or NRWTP is planned for an FY 1992 GPP entitled "Cs Removal System."

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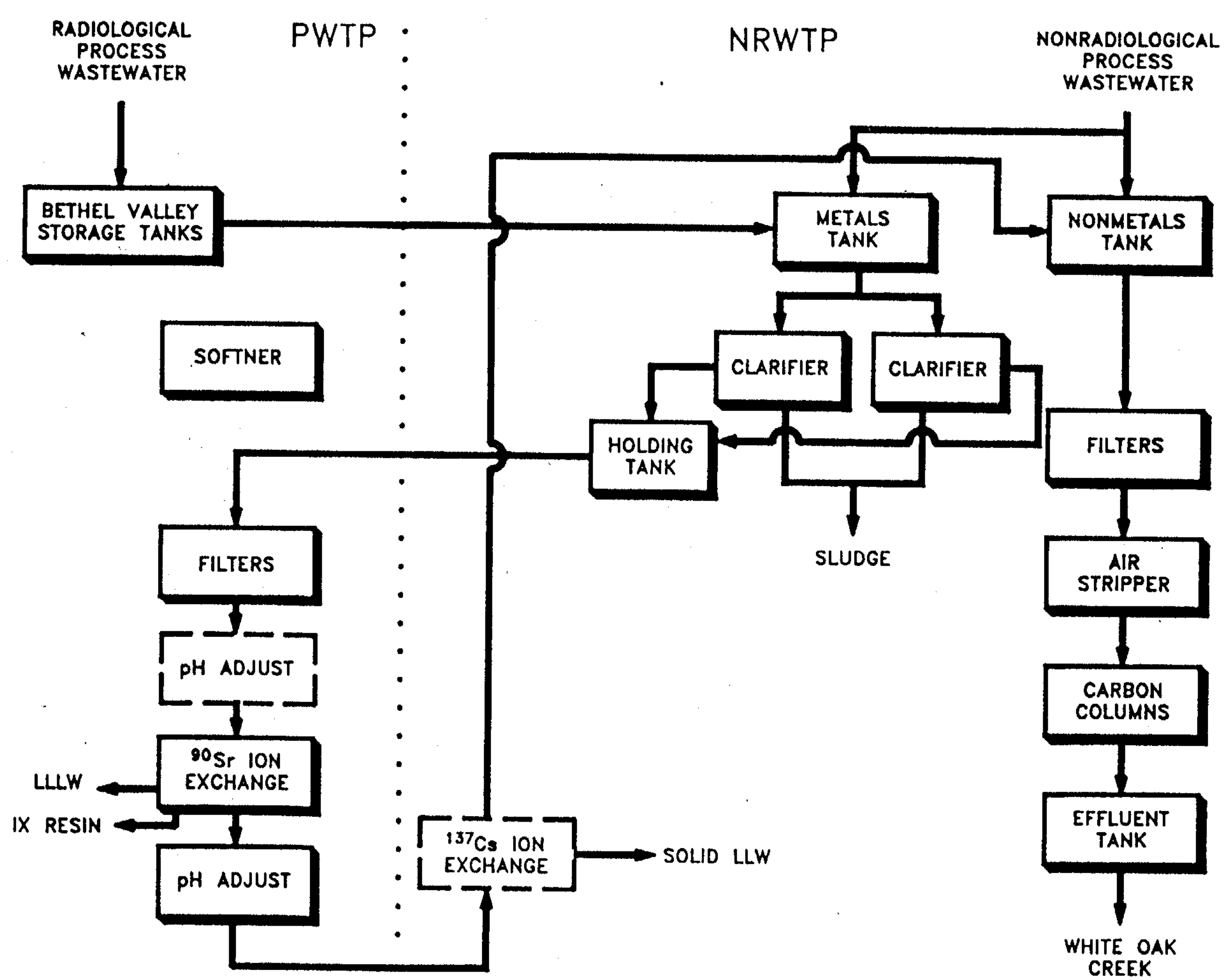

Fig. 5. Flowsheet for implementing Cs-137 removal capabilities in the Process Waste Treatment System.

Development studies are underway to support this project, and studies are being continued for the ferrocyanide precipitation process as a contingency measure.

PWTP Replacement

The zeolite system for long-term removal of Sr-90 and Cs-137 will be installed at the NRWTP site using some of the equipment described above. The reactor/clarifier will be used to remove particulates from the wastewater and for metals removal. Since the affinity of the zeolite for Sr-90 is relatively low, column change-out could occur as frequently as biweekly. Specially designed permanent columns will need to be operated in series to make this process efficient. Loaded zeolites will be transferred into disposable containers for dewatering and disposed of as Class II solid waste. This flowsheet completely eliminates the LLLWC presently generated by the PWTP [4000 gal/yr] (15 m^3/yr) and reduces the solid waste generation rate from 4700 to 3000 ft^3/yr (133 to 85 m^3/yr). A pretreatment facility will be installed upstream of the NRWTP to remove technetium, cobalt, and nitrate from waste streams that are expected to be generated in the future at ORNL (see Fig. 6). Some of these unit operations may generate LLLW. Two options are being considered for funding this project: (1) the FY 1992 LLWDF line item, and (2) an FY 1995 line item submitted by ORNL.

The LLWDF was originally defined as a line item project to build a treatment plant scheduled for operation in 1996 at the Class I landfill site. MMES Waste Management is presently considering diverting this funding to upgrade existing treatment plants on the Oak Ridge Reservation (including the NRWTP) to handle the LLWDF waste rather than building a separate facility. If the ORNL site is selected, the line item will likely install unit operations to remove technetium and a zeolite system to remove strontium and cesium at the NRWTP site. Selection of the LLWDF site is scheduled for late summer of 1990.

An FY 1995 line item initiated by ORNL would be used to install the NRWTP pretreatment system described above in case the LLWDF line item is not sited at ORNL. It will also install cobalt and nitrate pretreatment systems.

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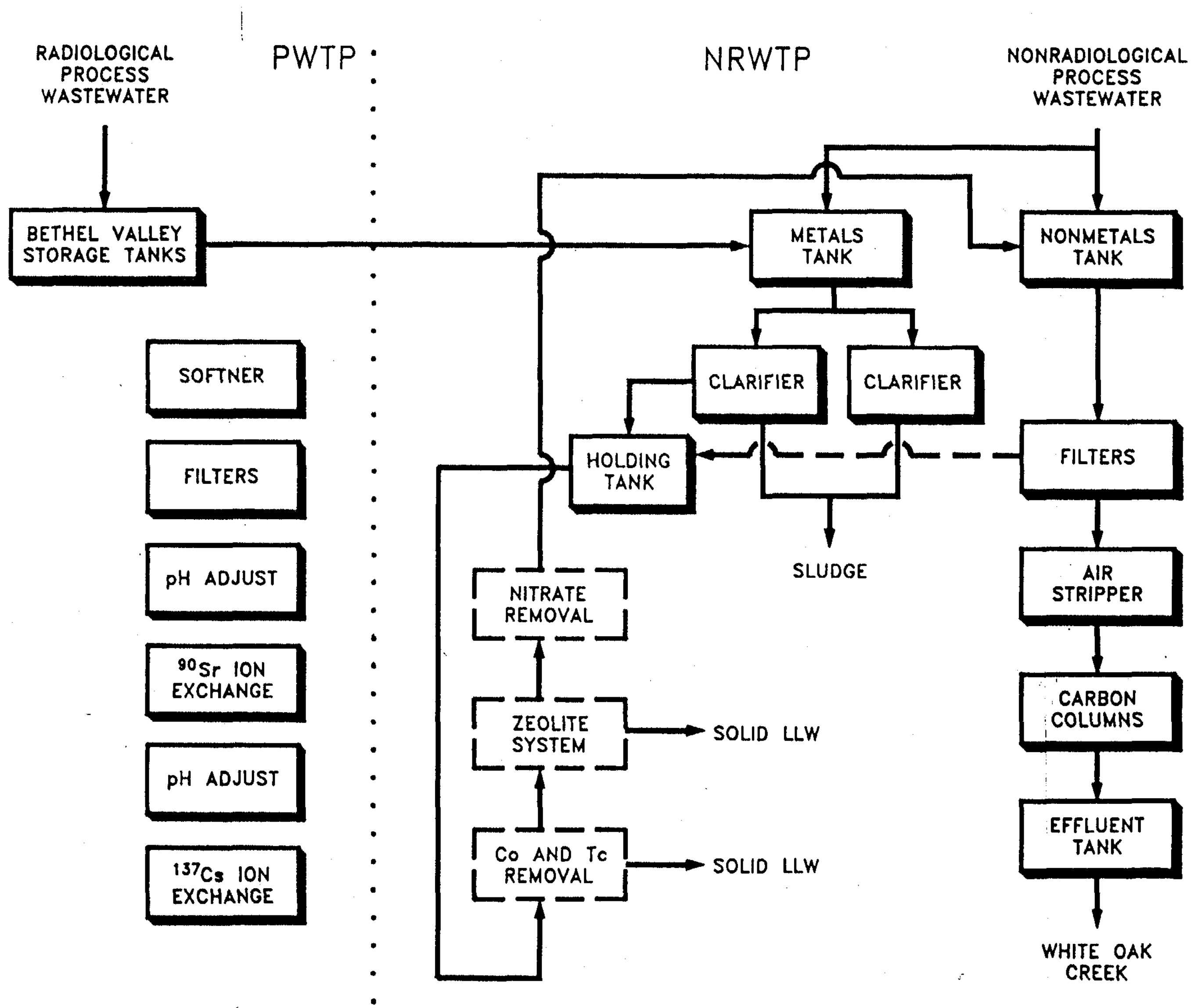

Fig. 6. Flowsheet for replacement of the Process Waste Treatment Plant.

SUMMARY

The current plan for upgrading the process waste system calls for replacing the existing PWTP with a new facility sited at the NRWTP contingent upon space availability. The present precipitation/organic-ion-exchange processes for removal of cesium and strontium will be replaced with more efficient filtration/zeolite-exchange unit operations. The new facility will also have the capabilities to remove technetium, cobalt, and nitrate which are not presently available at ORNL. Unfortunately, upgrades will also be required at the existing PWTP to keep the facility in operation until it can be replaced.

The upgraded process waste system will meet all present operational and regulatory goals while reducing the amount of secondary waste generated at the plant. The upgrades of the process waste system are expected to reduce secondary waste generation rates at the PWTP from 5,000 ft^3/yr (142 m^3/yr) of LLLW and solid LLW to 3,000 ft^3/yr [85 m^3/yr] (40%) of solid LLW while reducing the total annual LLLWC generation rate by 4,000 gal/yr [15 m^3/yr] (40%).

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